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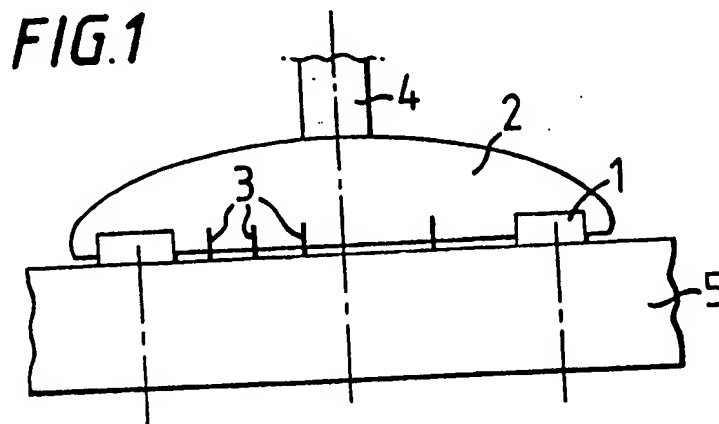
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G01N

(54) **Flooding detector**

(57) A detector for use in determining the state of the interior of a hollow metallic member 5 comprises a heater 1 affixed to the exterior of the member. The heater is surrounded by insulating material 2 except in the vicinity of the member itself. A series of temperature probes 3 embedded in the insulating material provides means by which a temperature profile may be obtained enabling the internal condition of the member to be determined. In an alternative arrangement the probes are arranged along a conductive flock extending between the heater and the hollow member, the block, heater and probe assembly being embedded in silicone rubber. The detector may be used to determine the state of flooding in offshore jacket members.



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FIG. 1

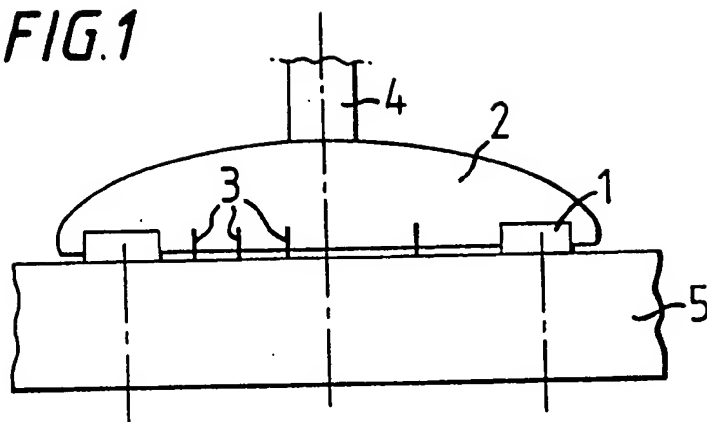
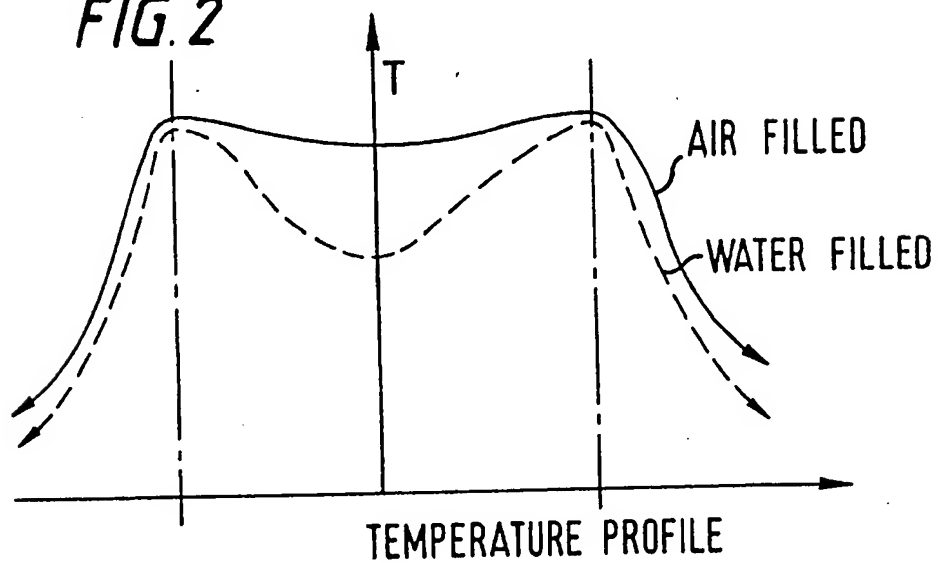


FIG. 2



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FIG. 3

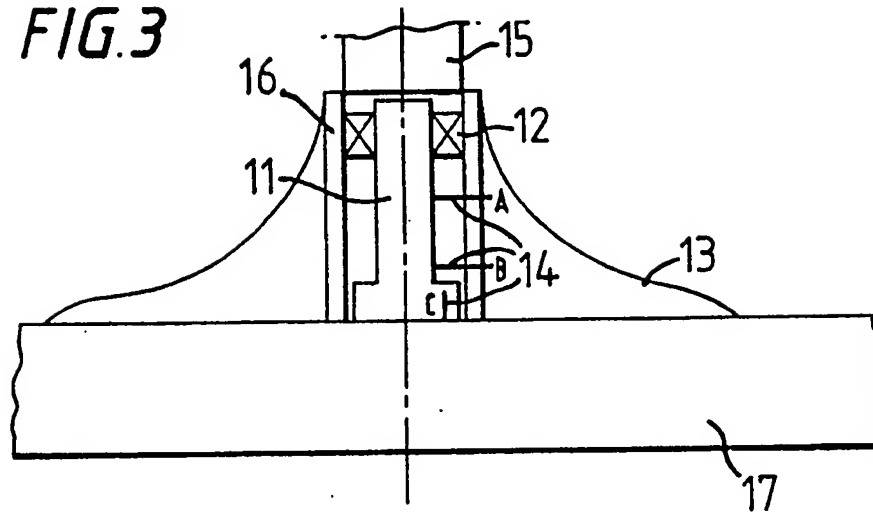


FIG. 4

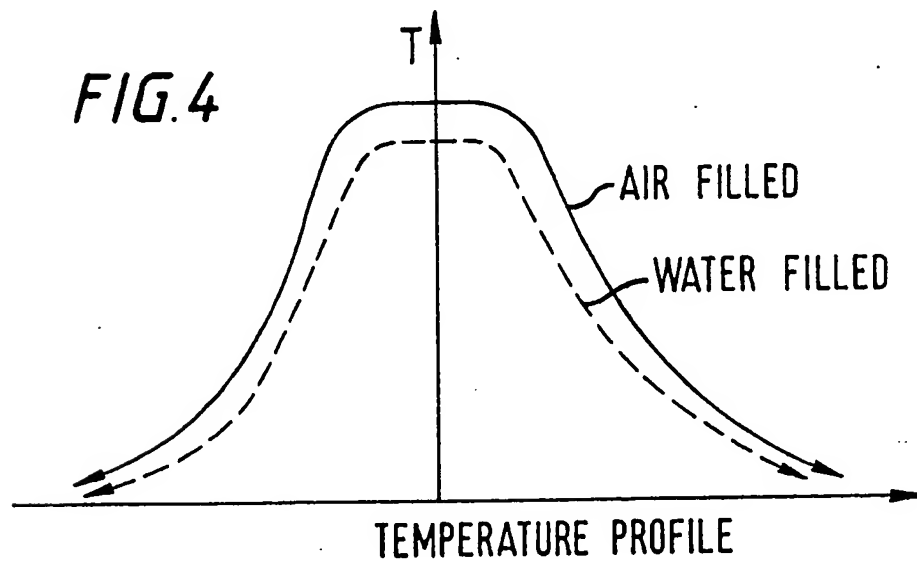


FIG. 5

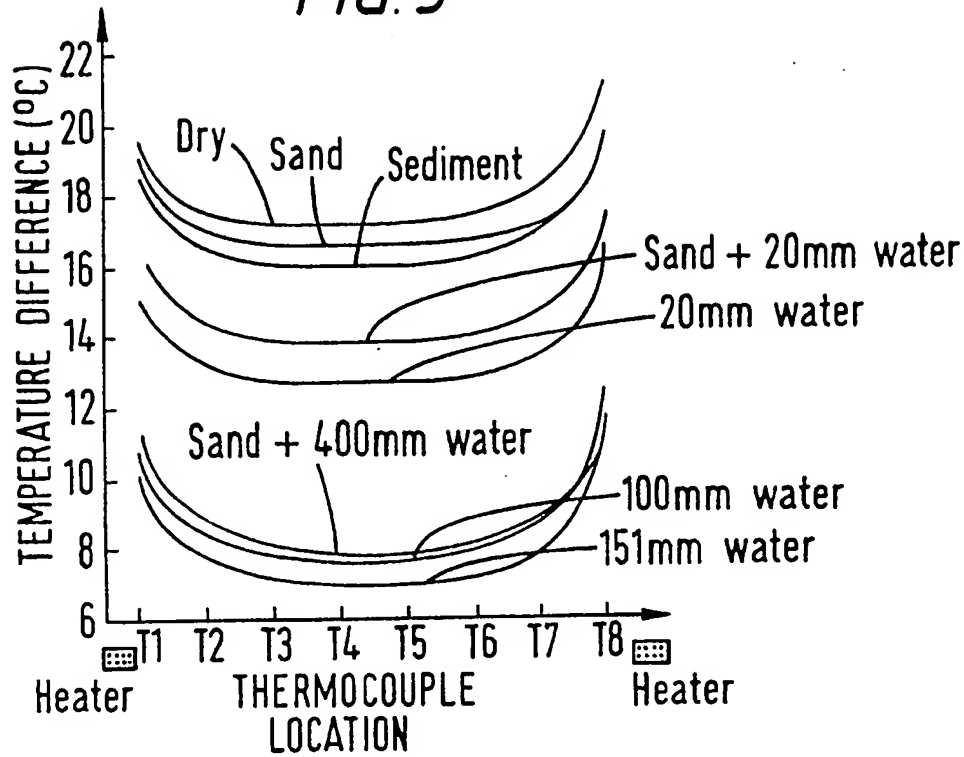
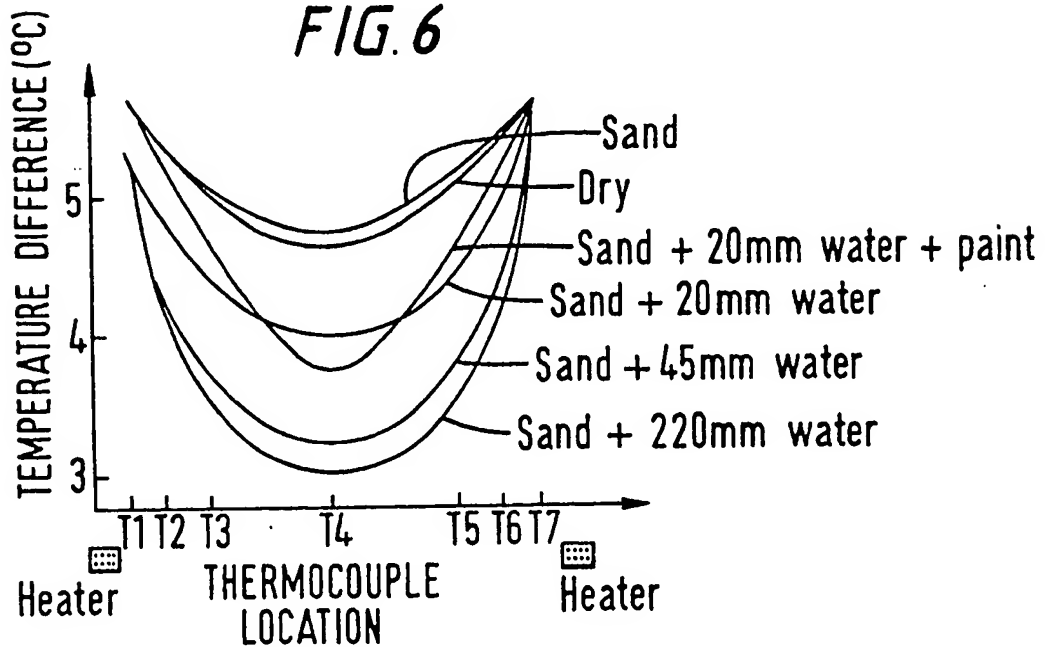


FIG. 6



FLOODING DETECTOR

This invention relates to apparatus and a method for determining by external measurement only whether a hollow body contains gas or liquids.

Many offshore oil fields are currently exploited by
5 free-standing production platforms. These consist essentially of deck modules resting on a jacket which is a tubular steel frame. The cross members and legs are in the form of hollow cylinders and caissons. Most members are sealed by fabrication welding and therefore should be in an empty state, i.e. containing only air, at
10 a pressure of one atmosphere. Vertical caissons are sometimes used for fuel oil storage and the oil may or may not be allowed to float on top of a layer of water.

In the first of the above situations there should be no water in the members. However, if water is present, then this is an
15 indication that through-thickness cracks are present somewhere in the system. It is desirable to know whether the members are flooded or not and if so to what level since this gives an indication of the extent of cracking, if any.

In the second situation again it is desirable to know at any
20 particular level whether air, oil or water is present since in the absence of cracks this is an indication of how much oil remains in store, or as before, an indication of cracking.

A number of techniques have been used for flooded member detection, all of which, however, possess certain disadvantages.

25 1. Ultrasonic techniques are currently favoured, but badly

internally corroded surfaces or internal debris scatter the ultrasound giving a "non-flooded" signal which may be wrong.

2. Gamma transmission requires an elaborate clamping mechanism to ensure that source and detector are diametrically opposed.

5 This may also be affected by debris (but giving false positives rather than negatives which makes it preferable to ultrasonics).

3. Neutron backscatter is only effective for wall thicknesses of less than 1 inch.

10 4. Vibro-detection is slow and requires a "signature" for each member in which there is absolute confidence. At present these techniques are not regarded as acceptable.

5. Installing pressure gauges would be an expensive retrofit activity and is discounted for existing platforms on grounds of cost.

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We have now discovered that by applying a heat source to a member and noting a temperature profile, the nature of the fluid at that particular level in the member can be determined since the heat transfer characteristics of metal/water, metal/oil and metal/air interfaces are different.

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If there is water inside a member at the level of the heat source the temperature profile will differ from that resulting from an empty member and from a series of measurements the state of flooding of the member can be deduced.

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Thus according to the present invention there is provided a detector, suitable for affixing to a hollow metallic, preferably steel, member, the detector comprising (a) a source of heat, positioned to heat the outer wall of the member, (b) an insulating material surrounding the source of heat except in the vicinity of the outer wall, (c) a series of temperature probes and (d) means whereby a temperature profile may be constructed from the measurements of the temperature probes.

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The source of heat may be an annular heater, the diameter of which is small in relation to the diameter of the member to which it is applied or a single point heater.

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In the former case the temperature probes will be embedded in the insulating material across the face of the apparatus along a diameter of the annulus. In use they will be in contact with the surface of the member undergoing test.

5 In the latter case the source of heat may be a heater in contact with a thermally conductive block positioned radially with respect of the member. In this alternative the temperature probes will be embedded in the insulating material in contact with and along the length of the thermally conductive block.

10 The heater may be of the electrically inductive type. If any annular heater is to be used it will be close to, but not necessarily in contact with, the wall of the member.

Suitable insulating materials include synthetic polymers, such as silicone rubber, expanded neoprene and polyurethanes.

15 The detector may adhere to the wall by virtue of applied force, suction, permanent magnetism or electromagnetism generated if an inductive heater is employed.

A detector according to the present invention has the following advantages.

- 20 1. It is small and cheap, and can be locally applied by a diver or a small ROV. (Remotely Operated Vehicle)
2. The heat transfer characteristics of steel to water and steel to air are markedly different and will swamp the effects of badly corroded interior surfaces, thin coatings and internal
- 25 debris.
3. No "signature" is required for the members to be examined.
4. No retrofit of components to the jacket is necessary.

According to another aspect of the present invention there is provided a method for detecting the state of the interior of a

30 hollow metallic, preferably steel, member which method comprises the steps of

- (a) applying a source of heat to the exterior of the member.
- (b) taking measurements from a series of temperature probes along a conducting surface and
- 35 (c) constructing a temperature profile for the conducting surface.

The conducting surface may be the member itself, in which case the temperature measurements are taken along its length, or a separate block in which case the block will be radially positioned with respect to the member and the temperature measurements will be taken along its length.

The invention is illustrated with reference to Figures 1 - 4 of the accompanying drawings wherein Figure 1 is an embodiment showing an annular heater, Figure 2 shows the resulting temperature profiles, Figure 3 is an embodiment showing a spot heater and Figure 4 shows the resulting temperature profiles.

With reference to Figure 1, the detector comprises an annular heater 1 embedded in a block 2 of silicone rubber as insulating material. A number of temperature probes 3 are embedded in the block to measure the temperature at different points on the diameter and a temperature profile is built up.

An umbilical 4 supplies power to and conveys signals to and from the detector.

The detector is positioned on the outer wall 5 of a caisson by a diver or a small ROV. It adheres to the wall with the heater 1 and temperature probes 3 in contact with the wall.

In Figure 2 the solid line illustrates a typical temperature profile provided by an air filled caisson and the broken line shows a profile corresponding to a water filled caisson.

With reference to Figure 3, the detector comprises a conductive block 11 surrounded by a heater 12 at one end and embedded in a block 13 of silicone rubber as insulating material. A number of temperature probes 14 A, B, C are embedded in the block. The difference in the temperatures at A and B will reflect the rate of heat transfer to the steel. Alternatively, measurement of the temperature gradient with respect to time at position C would also give a measure of the heat transfer rate to the steel and hence the state of flooding.

An umbilical 15 supplies power to and conveys signals to and from the detector.

A cylinder 16 is provided to act as a support and attachment

point for the insulating block 13 and the heater 12.

The detector is positioned on the outer wall 17 of a caisson by a diver or a small ROV. It adheres to the wall with the end of the block 11 remote from the heater 12 in contact with the wall 17 and temperature probes 14 in contact with the block 11 along its length.

In Figure 4, the solid line illustrates a typical temperature profile provided by an air filled caisson and the broken line shows a profile corresponding to a water filled caisson.

The invention is further illustrated with reference to the following examples:

Examples

The detector used consisted of an annular electrical resistance heater as described in the accompanying drawings thermally insulated on the outer side and protected by a thin steel mesh on the inner side. The inner side was placed against the member and eight thermocouples used to monitor the temperature profile across the diameter. The detector was bonded directly to a section of pipe of 762mm diameter and 41.5mm wall thickness. Temperature readings were made using Type T (copper/constantan) thermocouples connected to a Yokogawa Model 3088 Hybrid recorder.

Example 1

A series of tests were carried out using internal conditions in the pipe ranging from dry to flooded with and without contaminants such as sand and sediment. Temperature profiles were obtained by plotting the temperature difference above ambient against the thermocouple location using a constant power input of 230 Watts. The results are set out graphically in the accompanying Figure 5 and clearly show the different profiles obtained from dry and flooded members.

Example 2

A further series of tests were carried out under constant temperature conditions achieved by maintaining a constant temperature difference of 5.7°C at the thermocouple nearest the heating coil. In these tests the detector was formed around a moulded pad held in position on the pipe by suction. The results

are similarly set out in Figure 6 and again show the different profiles between dry and flooded members.

It can be seen from Figure 6 that where the pipe is coated with paint the dip in the curve is more marked. This is to be expected since the paint will tend to restrict the transfer of heat into and out of the member with a consequential drop in the measured temperature. This may be countered by altering the calibration or it may be preferred to remove the coating at the location of the test.

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Claims:

1. A detector, suitable for affixing to a hollow metallic member, the detector comprising
 - (a) a heater, positioned to heat the outer wall of the member,
 - 5 (b) an insulating material surrounding the source of heat except in the vicinity of the outer wall,
 - (c) a series of temperature probes, and
 - (d) means whereby a temperature profile may be constructed from the measurements of the temperature probes.
- 10 2. A detector according to claim 1 in which the heater is an annular heater.
3. A detector according to claim 2 in which the temperature probes are embedded in the insulating material across the face of the apparatus along a diameter of the annulus.
- 15 4. A detector according to claim 1 in which the heater is a single point heater in contact with a thermally conductive block positioned radially with respect to the member.
5. A detector according to claim 4 in which the temperature probes are embedded in the insulating material in contact with and along
20 the length of the thermally conductive block.
6. A detector according to any of the preceding claims in which the heater is of the electrically inductive type.
7. A detector according to any of the preceding claims in which the insulating material is a synthetic polymer.
- 25 8. A detector according to claim 7 in which the synthetic polymer

is selected from silicone rubber, expanded neoprene or a polyurethane.

9. A detector according to any of the preceding claims in which the metallic member is steel.

5 10. A method for detecting the state of the interior of a hollow member which method comprises the steps of:

(a) applying a source of heat to the exterior of the member,
(b) taking measurements from a series of temperature probes along a conducting surface and

10 (c) constructing a temperature profile for the conducting surface.

11. A method for detecting the state of the interior of a hollow metallic member as hereinbefore described and with reference to the accompanying drawings.

12. A detector for affixing to a hollow metallic member as
15 hereinbefore described and with reference to the accompanying drawings.

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